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In this report ~~two~~ methods of updating estimated fixes are discussed. An example ~~is~~ examined which favors the use of one method over the other. The report ends with a "plug" for the use of a method based on fix variance in place of either method previously discussed.

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U.S. ARMY INTELLIGENCE CENTER AND SCHOOL
Software Analysis and Management System

Bearing Selection For New Fixes

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PREFACE

The work described in this publication was performed by the Mathematical Analysis Research Corporation (MARC) under contract to the Jet Propulsion Laboratory, an operating division of the California Institute of Technology. This activity is sponsored by the Jet Propulsion Laboratory under contract NAS7-918, RE182, A187 with the National Aeronautics and Space Administration, for the United States Army Intelligence Center and School.

This specific work was performed in accordance with the FY-87 statement of work (SOW #2).

Bearing Selection For New Fixes

DISCUSSION

Bearing selection for a new fix is frequently done one of two following ways:

i) 'Exclude tested bearing from fix' method or 'exclude' method:

Iteratively
(a) compute all possible fixes with one bearing removed from the remaining bearings
(b) eliminate the bearing with the largest miss angle relative to the fix with the bearing removed if that miss angle is large enough
then STOP the iteration when either:
(a) there are less than three bearings left
(b) or when the largest miss angle is smaller than a specified value.

ii) 'Include tested bearing from fix' method or 'include' method:

Iteratively
(a) compute a fix with all the remaining bearings
(b) eliminate the bearing with the largest miss angle if that miss angle is large enough
then STOP the iteration when either:
(a) there are less than three bearings left
(b) or when the largest miss angle is smaller than a specified value.

The only difference between these two approaches is whether or not the bearing being tested is included in determination of the fix from which miss angles are measured.

Our first observation is that these two methods work much differently in practice. In judging which works better one would have to assess how well these two methods compare relative to two types of error:

i) How likely it is that bearings not from this emitter will be accepted. This is most easily measured by the range of angles which would be accepted.
ii) How likely it is that bearings from this emitter will be rejected.

This report only addresses a portion of this assessment. An example is given where it is shown that the 'exclude' method is subject to poor performance relating to the second type of error listed above. Since the 'include' method would not have the same problem, the example may be considered the basis for a preliminary preference for the 'include' method.

THE EXAMPLE

The example of concern to us is where two (or more) bearings come from approximately the same direction but the third (or remaining) bearing comes from a direction approximately 90 degrees different from the other bearings. See Figure 1.

This example was chosen because it behaves almost like a two bearing case. The first two bearings behave almost like one bearing. When the 'exclude' method is testing the third (or remaining) bearing, the uncertainty in the fix excluding that bearing becomes more significant to the test than the uncertainty in the bearing. Whether or not the test will accept the third bearing depends on error in the fix rather than error in the bearing. Small changes in the first two bearings greatly change the location of the intersection of those two bearings.

CONCLUSIONS

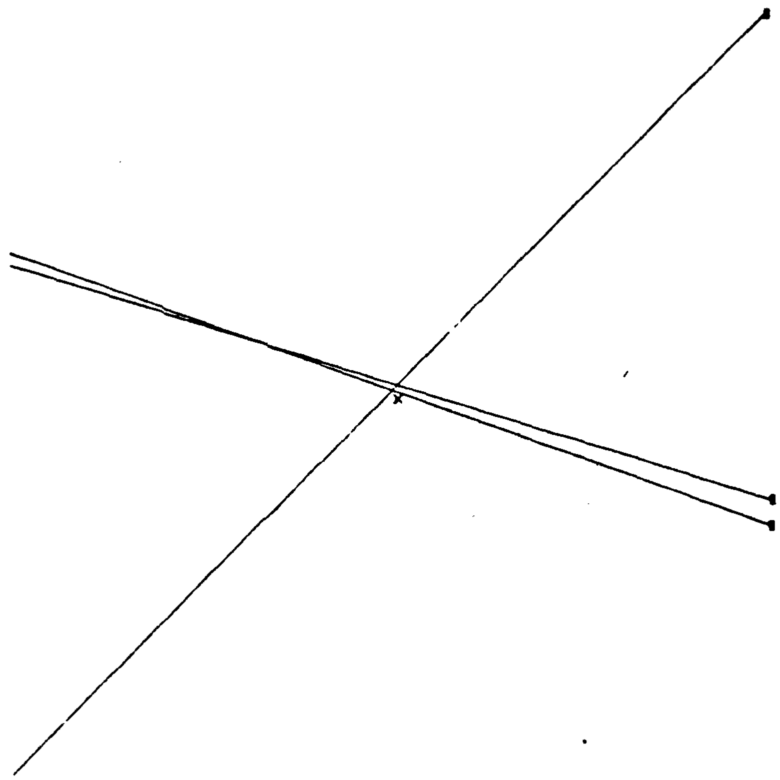
Implemented fix algorithms examined by MARC do not include 'fix uncertainty' in testing a bearing for inclusion in a fix. This is an error.

The 'exclusion' test is much more vulnerable to this problem than the 'inclusion' test since the reference fix for the 'inclusion' fix has one more bearing in it and hence is a more certain fix.

The sample size three case is the minimum sample size case so it is the case of greatest concern. Even if fixes were not attempted until larger numbers of bearings were accumulated, the iteration might prune one down to the three bearing case.

This memo is not reporting a complete analysis. The example is relevant but not necessarily decisive in comparison of 'inclusion' versus 'exclusion'. In fact an alternative solution that might be desired would be to exclude the three bearing case when two of the bearings are too close to being parallel Ultimately the preferred solution to the bearing selection problem is neither the 'inclusion' nor the 'exclusion' test. The preferred solution involves incorporation of fix variance in the model.

FIGURE 1



Note that all of the bearings are relatively close to going through the emitter but that one of the 'fixes' (intersections when n=3) used by the 'Exclusion Method' is far enough from the true location to cause bearing rejection. The example is exaggerated to make a point but similar issues would apply in less extreme cases.

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